

Controlling INSECTS and DISEASES of

the PECAN



U.S. DEPARTMENT
OF AGRICULTURE

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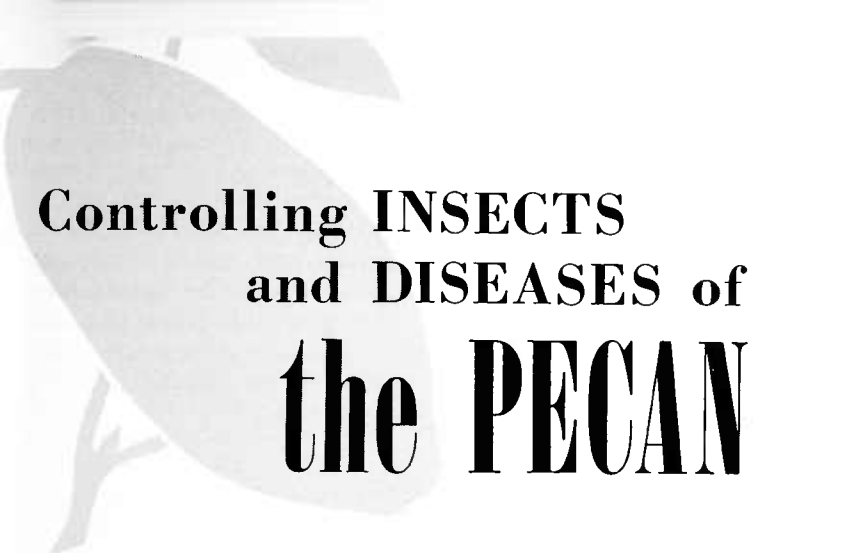
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Controlling INSECTS and DISEASES of the PECAN

Many kinds of insects and disease organisms attack pecan trees and threaten the crop of nuts. They do it in several ways. Some insects damage the bark or heartwood. Others tunnel or girdle the branches and cause them to break off. Still others attack the buds, leaves, or nuts. Some kinds of pests are present throughout the growing season; others are present for shorter periods, either early or late.

Disease organisms—principally fungi—that infect the pecan usually attack the growing tissues, including leaves, shoots, and nuts. In severely affected orchards, trees may be so badly injured that most of the leaves are shed or practically all the nuts are lost. Disease spreads most rapidly early in the growing season during periods of damp weather.

The growth of the pecan industry has brought new problems in controlling pests. The pests increase rapidly because large acreages of pecan orchards provide an abundant supply of the food they pre-

fer. Species that were not commonly present have transferred to pecans from hickories and other plants.

The damage caused by several of the major insects and diseases tends to be particularly severe in planted and topworked orchards comprised of large numbers of trees of a few varieties; in such orchards the damage is more severe than it is in native or seedling groves in which every tree is different.

The commercial pecan grower must control harmful insects and diseases to produce profitable crops of nuts. First, the insects and diseases affecting the trees must be identified; then effective control measures must be used. It is often a waste of time and money to apply control measures to trees of poor varieties or to those that are in a low state of vigor because of lack of care, inadequate soil fertility, or crowding.

Certain cultural practices will promote tree vigor, stimulate fruiting, and help to minimize the damage caused by some pests.

INSECTS OF THE PECAN

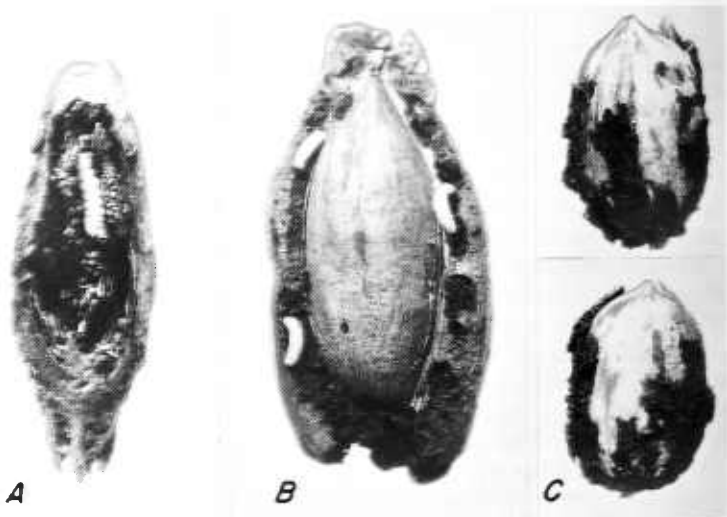
HICKORY SHUCKWORM

The hickory shuckworm is the most destructive insect that infests the pecan. It is generally distributed throughout the Pecan Belt, west to and including Texas.

Larvae of this insect attack the nuts from about the first of June until harvest. They tunnel in and destroy the interior of the nuts (fig. 1) until the shells harden late in

August. Nuts infested early fall to the ground. At least half the crop may be lost to shuckworms, especially when there is a light set.

Usually, it is difficult to see the entrance holes made by shuckworm larvae except under magnification. Their presence, however, may often be detected by a white stain around the point of entrance on freshly dropped nuts.



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Figure 1.—Damage caused by larvae of the hickory shuckworm: A, Larvae in immature nuts; B, larvae mining the shuck of a nearly mature nut; C, nuts showing shell stains and adhering parts of damaged shucks.

After shells have hardened, the larvae tunnel in the shucks and prevent the kernels from developing properly. Nuts heavily infested by shuckworms are likely to be poorly filled and to mature later than those free from this pest. Injured portions of the shucks sometimes stick to the nuts and interfere with proc-

essing. Shells often are badly stained.

Shuckworms also feed on hickory nuts, causing injury similar to that done to the pecan. Early in the spring, they may feed in phylloxera galls.

These insects pass the winter as full-grown larvae in the shucks on

the ground. The larvae are $\frac{1}{3}$ to $\frac{1}{2}$ inch long, creamy to dirty white, and have brownish heads. They transform into pupae, and the pupae into dark, inconspicuous moths.

In southern Georgia, the moths begin to appear the middle of February. Most moths of this generation emerge in April, but small numbers continue to appear well into summer. The spring development of the insect coincides with that of the nuts of native hickory, which set 2 to 3 weeks earlier than those of the pecan. Only the late-emerging moths of the spring brood lay their eggs on the foliage and small nuts of the pecan.

Few pecan nuts become infested with shuckworms before June. Starting in June, the shuckworm population increases rapidly with successive generations, of which there are four or five in the latitude of southern Georgia.

Control

No entirely satisfactory control of the shuckworm is known. However, 2 pounds of 25-percent EPN or Guthion wettable powder in each 100 gallons of water, applied as a spray, is fairly effective in preventing late season damage after shell hardening, and often results in improved quality nuts. Make three applications, the first about August 10 to 15 and the second and third at 2-week intervals. See Precautions, page 45.

If you have only a few trees or are not equipped to spray, you may reduce infestation by gathering and destroying the pecan shucks at harvest.

PECAN NUT CASEBEARER

The pecan nut casebearer causes damage throughout the Pecan Belt. Losses vary considerably from year to year and with the size of the crop. A light to moderate infestation in a heavy set of nuts may merely provide a desirable thinning, but if it occurs in a light crop, most or all of the nuts may be destroyed.

The casebearer passes the winter as a partly grown larva in a small, tightly woven cocoon (fig. 2), sometimes called a hibernaculum, which usually is found where a bud joins the stem. The larvae become active in spring about the time the buds begin to open. They feed for a short time on the buds, and then bore into the young, tender shoots.

Full-grown larvae are about one-half inch long; they have olive-gray to jade-green bodies and yellowish brown heads. They transform into pupae either in the tunneled shoots or in cocoons that they attach to other parts of the tree.

The rather inconspicuous dark gray moths usually emerge in May. They appear in largest numbers about the time the nuts are setting. They lay greenish white eggs on the blossom end of the nuts. Usually only one egg is laid in a cluster of nuts.

Most of the damage by this insect is caused in May and June by the first-generation larvae. Newly hatched larvae usually descend from the nut clusters to feed on the buds just below. After a few days they return to the clusters and attack the newly set nuts. Infested nuts are held together by silken threads (fig. 3). They are easily



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Figure 2.—Winter cocoon of the pecan nut casebearer at the base of a bud.

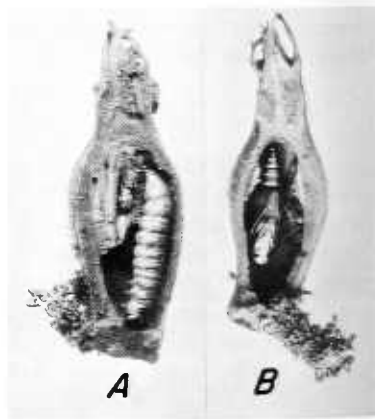
recognized by the mass of frass cast out by the larvae. In the course of its development, a single larva of this generation may destroy from

one to all the nuts in a cluster. A larva matures and pupates in one of the last nuts it attacks in a cluster (fig. 4).



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Figure 3.—Cluster of nuts infested by the pecan nut casebearer.



BN-3643

Figure 4.—Larva (A) and pupa (B) of the pecan nut casebearer within small nuts.

Moths of the second generation appear in late June and early July. Larvae of this generation also attack the nuts, but the loss is less be-

cause the nuts are larger, and an individual larva requires only one or two nuts for its development. Larvae of later generations feed mostly on the surfaces of the shucks and to some extent on the leaves; they do little damage. Larvae of the last generation in the season construct cocoons about the buds; in these, they overwinter. Three generations of this insect are most common, although four generations have occurred in Texas.

Control

Usually, no control is needed when the nut crop is normal or above normal, and not more than about 3 percent of the shoots of the previous year are infested with overwintering larvae. Under all other circumstances, and especially if there is a history of serious infestation, an insecticide program should be undertaken.

You can make an effective spray by mixing in each 100 gallons of water one of the following wettable powders: 2 or 3 pounds of 50-percent DDT; or 2 pounds of 25-percent EPN, 15-percent parathion, or 25-percent Guthion; or 3 pounds of 25-percent malathion. Or, you can mix 1½ pints of a 25-percent parathion emulsifiable concentrate in 100 gallons of water.

If you use a dust, apply a 2-percent parathion dust at the rate of 50 pounds per acre, or a 10-percent malathion dust at the rate of 40 pounds per acre. See Precautions, page 45.

A single application of any of these sprays or dusts will give adequate control of the nut casebearer

in most orchards. If the infestation is severe, make two applications about a week apart. Make the first application before many first-generation larvae enter the nuts, between about April 20 and May 25. Start applications when eggs are readily found on the tips of the young nuts. The eggs are very small but large enough to be seen without magnification.

In the latitude of Albany, Ga., the usual date to start applications is about May 15; in southern Texas, the last of April or the first of May; and in central and northern Texas, from May 5 to 25. The timing of the first application may be based on nut development and catkin shed. In northern Florida apply insecticide about the time the tips of the nuts turn brown, and in other areas about the time catkin shed is complete on such varieties as Schley, Stuart, and Mahan. Applications by airplane should be made shortly after the first larvae enter nuts.

PECAN WEEVIL

The pecan weevil (fig. 5) is a light-brown or grayish beetle about one-half inch long; it has a long beak. This insect infests the nuts and causes serious loss in pecan production in the Piedmont areas of the Southeastern States. In most years it causes some losses in other pecan-producing States, particularly in Louisiana, Texas, and Oklahoma.

The weevils do not ordinarily move far from the tree under which they emerge from the soil, provided there is a crop of nuts on that tree. Consequently, certain trees may be heavily infested year after year;



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Figure 5.—Pecan weevils on Schley pecans.

other trees of the same variety close by may have few, if any, infested nuts. Usually the trees most heavily infested in an orchard are those growing in low areas or adjacent to hickory trees.

Pecan varieties differ widely in their susceptibility to attack. Early-maturing varieties such as Stuart, Schley, Mahan, and Money-maker are most commonly infested. Late-maturing varieties such as Success, Teche, Mobile, and Van Deman usually are not attacked unless the crop on the early maturing varieties is very light or was de-

stroyed before the insect finished feeding and egg laying. Practically all kinds of hickory nuts are attacked.

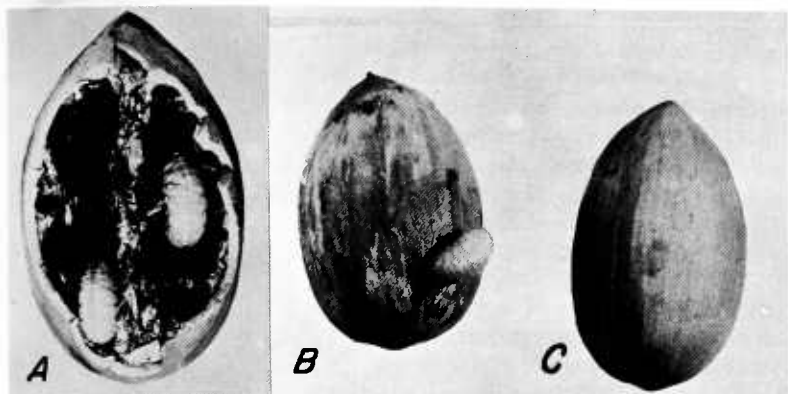
Pecan weevil damage may be one of two types, depending on the stage of nut development at the time attack occurs. The first type of damage is caused by attack before the nut shells become hard; this damage causes all punctured nuts to drop.

Female weevils usually begin depositing eggs in nuts after the kernels begin to form. Attack during this period causes the second type of damage; it leads to destruction of the interior of the nut and to adherence of the shuck to the shell. Nuts injured by the second type of damage (fig. 6) contain grubs that destroy the kernels, or they contain holes about one-eighth inch in diameter through which mature grubs may escape after destroying the kernels.

The first type of damage often passes unnoticed. However, it may destroy the entire crop if weevils are abundant and the crop is light. Such damage may be heavy even when a large crop is attacked. The second type of damage is generally noticeable at harvesttime, and may affect practically the entire crop in seasons when large numbers of weevils are present.

The time when adult weevils emerge from the soil varies with the season and the locality. In central Georgia they usually emerge between August 1 and September 1, and in central Texas after periods of heavy rainfall in August or early in September.

Egg laying begins about the last week in August; the actual date de-



BN-3636

Figure 6.—A, Nearly mature grubs of the pecan weevil within Stuart pecan; B, grub emerging through hole in nut; C, nut that has hole through which mature grub may escape.

depends upon the time of hardening of the kernels and the presence of weevils. Females drill holes through the shucks and shells, and place an average of three eggs apiece in separate pockets within the kernels.

Grubs emerge from the nuts between the last of September and the last of December, and sometimes later. They enter the soil to a depth of 4 to 12 inches and construct earthen cells, where they remain 1 or 2 years. They pupate between the first part of September and the middle of October and transform into adults in about 3 weeks. These adults remain in the soil until the following summer. The complete life cycle requires from 2 to 3 years.

Control

DDT is the most effective insecticide yet found for the protection of pecans from weevils. Use 6 pounds of a 50-percent DDT wettable powder in each 100 gallons of water or fungicide. Make two applica-

tions, the first when at least six weevils can be jarred onto a sheet spread on the ground beneath any tree known to have been infested in previous seasons, and the second 10 to 14 days later.

The first application may be needed by the first week in August in Georgia, Alabama, Mississippi, and Louisiana; it may be needed the first or second week in August in South and North Carolina, and after the first heavy rain late in August or early in September in Texas.

When spraying for pecan-scab control, delay the last seasonal application of the fungicide until you make the first application of DDT for weevil control, since recommended fungicides can be used with DDT.

Toxaphene will also control the pecan weevil. Mites and aphids do not increase as rapidly after its use as they do after the use of DDT. Use 6 pounds of a 40-percent toxaphene wettable powder or 2½ pints

of an emulsifiable concentrate containing 1 pound of toxaphene per pint or the equivalent of other toxaphene formulations to prepare 100 gallons of spray. Toxaphene should not be used with Bordeaux mixture but can be used with zineb.

EPN will control light and medium infestations of the pecan weevil. Mix 2 pounds of a 25-percent EPN wettable powder in each 100 gallons of water. Make three applications beginning August 10 to 15 as recommended for the hickory shuckworm. EPN can be used with fungicides recommended for scab control.

To determine the time for the first insecticide application, start jarring the trees about a week before you expect the application may be needed. See Precautions, page 45.

If you have only a few pecan trees or are not prepared to spray, you can reduce weevil injury about 50 percent by lightly jarring the limbs and gathering the weevils. You should begin jarring for control at the time indicated for determining spray dates; repeat weekly until about September 15. To determine the presence of weevils, you need to jar only a few of the trees known to be the most heavily infested year after year. If the weather is dry, few weevils will be taken and fewer jarrings will be needed until rains soften the ground.

To collect the weevils, place harvesting sheets under the trees and jar each limb lightly two or three times to dislodge the insects. Use a padded pole or a pole with a metal hook bolted to one end. It may be

necessary to climb high trees and jar each limb with the foot. Pick up the weevils from the sheets and kill them by placing them in a bucket or can containing kerosene. The dislodged weevils will remain quiet on the sheets long enough to be picked up.

APHIDS

Several species of aphids infest pecan trees; the most destructive is the black pecan aphid.

Practically all important pecan varieties are affected by aphids, especially in the South and Southeast, and at times in other parts of the Pecan Belt. The presence of Bordeaux mixture or DDT on the leaves sometimes seems to cause the aphids to increase in numbers.

The first sign of injury on the leaflets is a bright yellow area where the insect has fed (fig. 7). This yellow area eventually turns brown. As the season advances and the aphids increase in numbers, the entire leaf may drop prematurely.

Aphids feed on both sides of the leaflets and prefer the shaded, inner parts of the tree. As injured leaflets drop, the aphids migrate toward the outside of the tree. Premature dropping of many leaves cuts off the supply of plant food (fig. 8); it prevents the proper filling of the nuts and reduces the following year's crop.

The black pecan aphid passes the winter in the egg stage in crevices in the bark. Late in March the eggs hatch into wingless aphids, which move out to the opening buds and leaves where they feed until fully grown.



Figure 7.—Pecan leaf injured by the black pecan aphid. Note aphids on injured areas.

At first, the aphids are light green, but after feeding a short time they become dark green to almost black. When fully grown, they give birth to living young. Some aphids develop wings and fly to other parts of the same tree or to other trees.

About 15 successive generations occur through the season. Each mature aphid produces about 60 young. Under favorable conditions a very heavy infestation may develop from a low-population

level within a 3- or 4-week period. Examine orchards weekly from July through September to detect such increases before they reach an advanced stage. With the approach of cold weather, the insects lay eggs for the overwintering generation.

Three species of yellow aphids—the black-margined aphid, and two related species of *Monellia*—often occur in large numbers on the undersides of the leaves. The extent of the injury they cause is unknown, but they excrete large quantities of honeydew, which makes the leaves sticky and supports the growth of a sooty mold that interferes with the functioning of the leaves. Development and seasonal histories of these aphids are similar to those of the black pecan aphid.

Control

The black pecan aphid and other aphids that may be present can be controlled with parathion or malathion applied in dilute, semiconcentrated, or concentrated sprays. They can be controlled also with parathion dusts.

In dilute sprays, add 1 to 1½ pounds of 15-percent parathion or 2 pounds of 25-percent malathion wettable powder to each 100 gallons of water; add these wettable powders either alone or in combination with fungicides and, if needed to control mites, wettable sulfur.

In semiconcentrated or concentrated sprays, use sufficient material to apply 1 pound parathion or 1¼ pounds malathion per acre.

A dust containing either 1 percent of parathion or 1 percent of



BN-3833

Figure 8.—Pecan trees defoliated by the black pecan aphid.

parathion plus 40 percent of sulfur, applied at the rate of 50 pounds per acre, has also been effective.

In airplane applications, good results against aphids have been obtained in Louisiana by applying to each acre of pecan trees either 1 pound of parathion ($\frac{1}{2}$ gallon of 25-percent emulsifiable concentrate) in 5 gallons of water, or 1.25 pound of malathion (1 quart of 57-percent emulsifiable concentrate) in 4 gallons of water. In Georgia, airplane applications of 1 pint of 40-percent TEPP emulsifiable concentrate in 5 gallons of water per acre of pecan trees have been effective. Airplane applications of parathion or malathion require a following period of about 48 hours without heavy rainfall to give best results.

The black pecan aphid can be controlled also by applying a spray made by mixing one of the following with each 100 gallons of water: 1 pint of demeton emulsifiable concentrate (2 pounds of demeton per gallon of concentrate); $1\frac{1}{2}$ to 2 pounds of 25-percent EPN wettable powder; $1\frac{1}{2}$ to 2 pounds of Guthion wettable powder; or one-half pint of Trithion emulsifiable concentrate (4 pounds of Trithion per gallon of concentrate). See Precautions, page 45.

The black pecan aphid varies so much in its abundance that no set spray schedule can be given for its control. For best results begin treatments as soon as yellow spots appear on the foliage. In some seasons this may be as early as May;

in other seasons, treatment may not be necessary.

A single treatment may hold the aphid population in check for 3 weeks or more. Be sure to cover both surfaces of the leaves with the spray. Give special attention to the inner parts of the trees, where the aphids are usually most numerous early in the season. It is useless to apply an insecticide after many of the leaves have dropped and the aphid population is large.

If sufficient mites are present to require treatment, apply an insecticide such as parathion, which will control both mites and aphids at the same time. Use malathion in situations or locations where it is unsafe to use the other recommended insecticides.

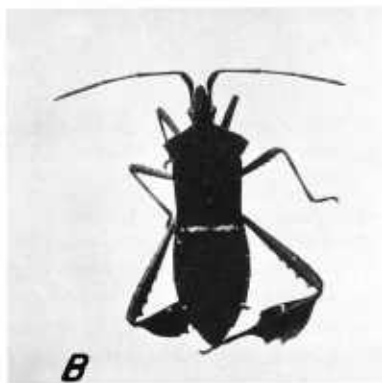
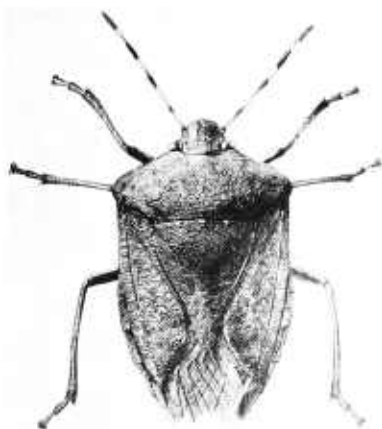
If other species of aphids become abundant, control can be effected with the treatments recommended for the black pecan aphid.

PLANT BUGS

The southern green stink bug (fig. 9, *A*), the leaf-footed bug (fig. 9, *B*), and similar bugs sometimes cause black pit and kernel spot of pecan nuts.

Black pit is indicated by a darkening of the insides of the immature nuts, which is followed by premature dropping. The pecan weevil and the hickory shuckworm cause a somewhat similar condition.

Kernel spot (fig. 10) consists of brown spots from $\frac{1}{16}$ to $\frac{3}{16}$ inch in diameter forming a pithy, porous area. The injury cannot be detected until the nuts have been shelled. The spots are bitter, but this bitter taste does not extend to the rest of the kernel. Nuts will

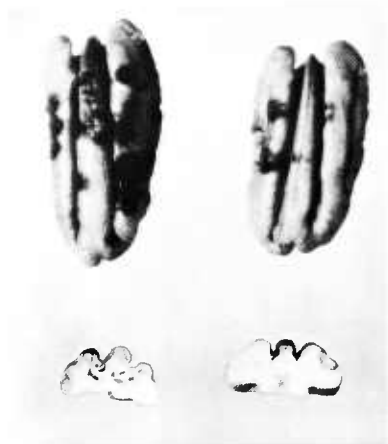


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Figure 9.—*A*, Southern green stink bug; *B*, leaf-footed bug. Enlarged.

drop if the bugs attack them before the shells have become hard (black pit), but after the shells have hardened the nuts do not drop and spots on the kernels are formed.

The severity of black pit and kernel spot varies with the abundance of plant bugs in an orchard, and the abundance of bugs depends on the native plants or cover crops present on which they breed.



BN-3624

Figure 10.—Kernel spots on ridges and edges of the kernels of Schley pecans.

The various plant bugs that cause black pit and kernel spot have somewhat similar life habits. The southern green stink bug, which usually is the most prevalent, is shield shaped and about one-half inch long. It spends the winter in trash or similar shelter in or near the orchard. In spring it lays eggs in clusters underneath the leaves of weeds, cover crops, or other low-growing plants. These plants serve as food for the bugs until they become fully grown. There may be as many as four generations of these bugs in a year. Pecan nuts are attacked only by the mature bugs, which fly to the trees from plants on which they developed.

Control

The use of proper cover crops and orchard sanitation are the best methods of controlling plant bugs that cause black pit and kernel spot. Do not plant cowpeas, soybeans, or *Crotalaria striata* as sum-

mer cover crops in or near the orchard. Till the soil in the orchard two or three times during the summer to destroy wild hosts such as beggarweed, thistle, jimsonweed, and maypop. If the orchard is in permanent pasture or being grazed, and plant-bug hosts are present, mow several times during the summer. For winter cover crops use legumes such as hairy vetch or re-seeding crimson clover.

No effective insecticide treatment to control these plant bugs is known.

PECAN LEAF CASEBEARER

The pecan leaf casebearer occurs most commonly in northern Florida and the southern parts of Georgia, Alabama, Mississippi, Louisiana, and Texas.

The insects pass the winter as immature larvae in small cocoons about the buds, similar to cocoons constructed by the nut casebearer. In spring, the small larvae leave their winter cocoons and attack the unfolding buds and foliage (fig. 11). When the infestation is heavy, they may keep pecan trees in a semidefoliated condition for 3 or 4 weeks.

On reaching maturity, the larvae are slightly over one-half inch long, dark green, and have shiny, dark-brownish heads; they transform to pupae within a case they construct about themselves while feeding.

The small, grayish brown moths appear from about the middle of May until the first part of August. The moths deposit their eggs on the lower surfaces of the leaves along a vein or near the junction of a vein



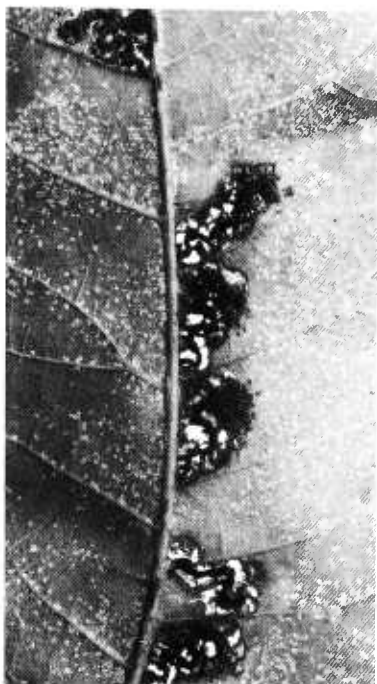
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Figure 11.—Young pecan buds injured by larvae of the pecan leaf casebearer.

with the midrib. Young larvae that hatch from these eggs feed sparingly on the undersides of the leaves (fig. 12) from the middle of May until November, rarely attaining a length of more than one-sixteenth inch by fall. Late in August or early in September the immature larvae begin to leave their cases on the under surfaces of the leaves and migrate to the buds, where they construct their winter cocoons. The insect passes through only one generation a year.

Control

Control the leaf casebearer by spraying the trees either when the buds begin to open or in the summer from late in June until the middle



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Figure 12.—Feeding cases and injury to lower surface of pecan leaf by newly hatched larvae of the pecan leaf casebearer. Enlarged.

of August. Use 2 pounds of a 15-percent parathion wettable powder or 3 pounds of a 25-percent malathion wettable powder in each 100 gallons of water. If you are following a spray schedule to control scab, add the insecticide to the second prepollination application if two prepollination applications are recommended, or to the last fungicide application in July.

Airplane applications of a dust or spray will control the insects when they resume feeding in spring. Apply a 5-percent malathion dust at the rate of 40 pounds per acre;

or apply a mixture containing 5 gallons of a 5-pound-per-gallon malathion emulsifiable concentrate in each 50 gallons of water. See Precautions, page 45.

SPITTLEBUG

The spittlebug is common on pecan in northern Florida, along the gulf coast, and in parts of Kentucky and Illinois. It may attack pecan trees also wherever they occur along the Atlantic coast from Massachusetts to Florida and westward to Kansas.

The young bugs, usually several together, produce masses of white, frothlike material about the buds, tender shoots, or nut clusters (fig. 13) in spring, beginning shortly after the nuts are set, and again in midsummer. They suck the juices from the parts they attack. Heavy

infestations kill the terminal shoots, which results in a smaller crop.

Adults are pale brown, have a reddish tinge, and are about three-eighths inch long. They are commonly called froghoppers because of their resemblance to frogs. They deposit eggs in small slits in the bark twigs of the previous season's growth that are one-half inch or smaller in diameter; usually they deposit several eggs to a slit.

The insect overwinters in the egg stage.

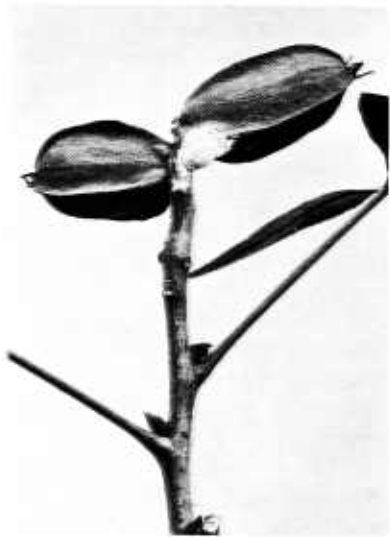
Control

Light infestations of spittlebugs do not cause sufficient damage to make control necessary. If spittlebugs become abundant, they may be controlled with one application of parathion or toxaphene about the middle of May. Use either 2 pounds of 15-percent parathion wettable powder or 2½ pounds of 40-percent toxaphene wettable powder in each 100 gallons of water.

If you are using a scab-control schedule, add the insecticide to 100 gallons of fungicide in the second prepollination application, but do not use toxaphene with Bordeaux mixture. See Precautions, page 45.

FALL WEBWORM

Fall webworms are caterpillars that feed in colonies and make unsightly webs on pecan trees during summer and fall. Usually all the members of a colony hatch from a mass of eggs deposited on a leaf by a single moth. The caterpillars feed on both surfaces of the leaves, and enlarge the web as they need more leaves.



BN-3625

Figure 13.—Pecan nut cluster showing spittle-like substance produced by the spittlebug.

When fully grown, the caterpillars are a little more than one inch long and are covered with long white and black hairs. They spin flimsy cocoons beneath loose debris on or just below the surface of the soil. Usually there are two broods a year. The second brood, usually the larger, feeds during fall.

Control

Fall webworms can be killed with a spray application containing DDT, parathion, EPN, Guthion or malathion. (Use a wettable powder.) Mix 2 pounds of 50-percent DDT, 15-percent parathion, 25-percent EPN or Guthion, or 3 pounds of 25-percent malathion wettable powder in each 100 gallons of water. Control is needed only when the insects are very numerous in an orchard, and should be undertaken when the caterpillars are small. See Precautions, page 45.

If there are not many webworms, it may be practical to remove the webs from the trees before the caterpillars have left them—preferably before they have done much feeding. Use a long-handled tree pruner or a bamboo pole with a hook at the end.

WALNUT CATERPILLAR

Walnut caterpillars feed in groups; they often eat all the leaves on small trees or on certain limbs of large trees (figs. 14 and 15). They do not form webs on the leaves.

In the South, the first generation appears in June and July, and the second generation in late August and September. As they grow, the



BN-3822

Figure 14.—Walnut caterpillars clustered on trunk of pecan tree.

caterpillars molt, or shed their skins, several times. In preparation for molting, they go down to a large limb or to the trunk of the tree and form a compact mass. After shedding their skins, they go back toward the ends of the branches and resume their feeding.

Control

The same spray treatments recommended for the fall webworm will control this insect. Caterpillars clustered on the trunk or limbs of a tree (fig. 14) may be destroyed by crushing or burning.



Figure 15.—Colony of walnut caterpillars on a pecan shoot.

TC-9711

TWIG GIRDLER

The twig girdler often girdles the twigs of pecan and other trees late in summer and during fall (fig. 16). The injured branch may break off and drop to the ground, or it may remain on the tree. This insect generally is present wherever pecans are grown. It is especially abundant in orchards near timberland where hickories and persimmons abound.

Twig girdlers are brown beetles $\frac{1}{2}$ to $\frac{5}{8}$ inch long. They lay eggs in the twigs that they girdle, and these eggs hatch into whitish, leg-

less grubs. The grubs make little growth during the fall and winter months, but in spring they grow fast and tunnel in the twigs. They complete their growth and transform into beetles during the latter part of August. Usually, one year is required for development of the insect, although some individuals do not complete development until the second season.

Control

To reduce damage that might occur in following years, gather and burn the severed branches late in fall or in winter or early spring,



BN-3621

Figure 16.—Twig girdler girdling a pecan branch.

when the eggs and grubs are in the twigs. Gather all branches lodged in the trees, those on the ground, and those from infested nearby trees such as hickory and persimmon.

Apply a spray to prevent damage in orchards that have a history of infestation. Use 4 pounds of a 50-percent parathion wettable powder, or 2 pounds of a 25-percent EPN or Guthion wettable powder in each 100 gallons of water. Make three applications at 2-week inter-

vals, beginning when the first injured branches are noticed late in August. See Precautions, page 45.

PECAN PHYLLOXERA

Swellings, or galls (fig. 17), occasionally appear on leaves, leaf-stalks, succulent shoots, or nuts of the current season's growth. These galls are caused by small insects known as phylloxera, which are closely related to aphids. One or more species are found in almost all sections of the Pecan Belt, but



BN-3638

Figure 17.—Galls of phylloxera on a pecan twig.

only one species has been reported as doing serious damage.

The attack of this insect causes the shoots to become malformed, weakened, and finally to die. Sometimes an entire limb may die. Especially serious damage has been reported from Arkansas, Louisiana, Mississippi, Oklahoma, and Texas.

The insects pass the winter in the egg stage in protected places on the branches. The young appear in spring about the time the buds unfold. An insect inserts its beak into the new growth, and a gall forms that soon envelops the insect. The insect matures within the gall and lays a large number of eggs. The young insects that hatch from these eggs develop into winged forms. Usually late in May or early in June, the gall splits open and releases the insects.

Control

Spray the trees thoroughly with BHC, lindane, or malathion during the delayed dormant period; do this before buds show 1 to 2 inches of new growth and before the galls appear. Use $2\frac{1}{2}$ pounds of BHC containing 10-percent of the gamma isomer, or use $1\frac{1}{4}$ pounds of 25-percent lindane wettable powder, or use 3 pounds of 25-percent malathion wettable powder in each 100 gallons of water.

Dinitro materials may be applied only when the trees are dormant, from late February until the buds begin to swell. To each 100 gallons of water, add 3 quarts of 36-percent dinitro-o-sec-butylphenol liq-

uid, or add a mixture containing 2 pounds of 40-percent dinitro-o-cyclohexylphenol powder plus a 2-percent dormant oil emulsion. See Precautions, page 45.

OBSCURE SCALE

The obscure scale is a serious pest of pecans in Texas, Louisiana, Arkansas, and Mississippi. It also occurs in other parts of the Pecan Belt. Its body is covered with a circular scalelike substance, usually dark gray, similar to the color of the bark, so that the insect is difficult to detect until it becomes abundant. It attacks the branches and trunk of the tree. The bark of heavily infested branches appears roughened or scaly (fig. 18).



TC-9712

Figure 18.—Obscure scale on pecan twig.
Enlarged.

This scale insect sucks the sap from plant tissues. The greatest injury comes from the gradual killing of branches less than 3 inches in diameter. Larger branches are seldom killed, though they may be so weakened that they will not produce normal nuts. The slow, progressive killing of infested branches reduces the number of fruiting shoots and weakens the tree, making it subject to attack by borers.

This insect has only one generation each year. The young, or crawlers, are present from about the middle of May until early in August. Soon after they hatch, the crawlers settle on the bark, insert their beaks, and begin to form their waxy scale coverings. They gradually increase in size and, except for the adult males, do not move around.

Control

Spray infested trees thoroughly with a dormant-oil emulsion before the buds begin to swell, preferably in January or February. If the trees are in a weakened condition, use a spray material containing 2 percent of oil, but if they are vigorous, use one containing 3 percent of oil. Weak, slow-growing trees are more subject to oil injury than are vigorous trees. Commercial oil emulsions are made in different strengths; dilute them to the desired strength according to directions on the containers.

MITES

Several species of mites attack pecan trees throughout the Pecan

Belt. A heavy infestation causes serious loss of foliage. The most common and injurious mite is known only by its scientific name, *Tetranychus hicoriae*. It is pale green, and so small that it is barely visible without magnification. It feeds principally on the undersides of the leaves, but may occasionally be found on the upper sides.

Infested leaflets first show a slight discoloration about the midrib, where the mites usually start to feed. Later the discoloration spreads outward, and the leaflets look as if they have been scorched. Fresh scorch injury appears as dark brown or liver-colored blotches, and old scorch injury as dead areas of irregular size and pattern. Severely injured leaflets turn brown and drop off. An infestation generally starts on the lower branches of the pecan trees and spreads upward.

The life history and habits of *hicoriae* have not been studied in detail, but they seem to be similar to those of the two-spotted spider mite, a species that occurs on many kinds of plants throughout the United States. Injury has been observed in June, but seems to be most severe during August, September and early October. The mites develop most rapidly in hot, dry weather. There are several generations each year.

Other species of mites sometimes occur along with *hicoriae* or instead of it, particularly in Louisiana and Texas. One species, *Eriophyes caryae*, rolls the edges of the leaflets, and others, *Brevipalpus* spp.,

feed along the veins on the undersides.

Control

Spray the trees with 2 pounds of 15-percent parathion wettable powder, or its equivalent, in each 100 gallons of water, whenever a mite infestation becomes evident and before it has caused the foliage to drop. Instead of parathion, you may mix in each 100 gallons of water one of the following: 1 pint demeton emulsifiable concentrate (2 pounds of demeton per gallon); 2 pounds 25-percent EPN wettable powder; 2 pounds 25-percent Guthion wettable powder; 2 pounds 18.5-percent Kelthane wettable powder; or 1 pint malathion emulsifiable concentrate (5 pounds of malathion per gallon).

If the infestation persists; make a second application after about 10 days. In the western portion of the Pecan Belt, where mites other than *hircoriae* are likely to occur, add 4 pounds of wettable sulfur to the insecticide spray material. Treatments for mites can be combined with those for aphids and disease control, if the treatments are needed at or near the same time. See Precautions, page 45.

PECAN BUD MOTH

The larvae of the pecan bud moth often cause serious damage to pecan nursery stock by feeding on and in the terminal buds and foliage. Also, the larvae occasionally defoliate large pecan trees, feed on the tips of and bore into the young nuts in spring, and infest the shucks in fall.

The adult is a small gray moth;

it has blackish brown patches on the forewings and a wingspread of about two-thirds inch. The insect overwinters in the adult stage. Overwintering moths start egg-laying about the time the buds begin to open, and place their eggs on the twigs near buds. Later, after the foliage appears, they lay most of the eggs on the upper surfaces of the leaves. Larvae feed for about 25 days. When fully grown they are yellowish green, have dark-brown heads and necks, and are five-eighths inch long. There are probably five or six generations each year.

Control

Young nursery trees should be kept in a strong, healthy condition by proper cultivation and fertilization. Vigorously growing trees are better able than slow growing ones to withstand attacks of the pecan bud moth.

Spray infested trees with 2 pounds of 50-percent DDT, or 15-percent parathion wettable powder in each 100 gallons of water; or apply a 2-percent parathion dust at the rate of 20 pounds per acre.

Airplane applications of parathion dust have given good control on young nursery trees. Four or five applications should be made at intervals of 2 to 3 weeks, beginning when damage is first observed. Control is seldom necessary in bearing orchards. If bud-moth damage is threatened, apply insecticide as needed. See Precautions, page 45.

FLATHEADED APPLE TREE BORER

The adult flatheaded apple tree borer (fig. 19) is present in pecan

orchards from spring to late fall. It attacks pecan trees of nearly every age wherever they are grown. Injury is usually confined to trees that have already been weakened from some other cause, such as those injured in cultivation, by cold, drought, or sunscald, or retarded by transplanting. Borers usually work on the sunny side of a tree trunk.



BN-3634

Figure 19.—A flatheaded apple-tree borer feeding in wood of a tree.

Injury results from the tunneling of the borers in the bark and sapwood of the trunk. Trees 2 inches or less in diameter may be girdled and killed, and larger trees may be weakened. The presence of one borer in a tree often leads to further attack. The insects disclose their burrows by pushing frass

from the cracks in the bark. Injured spots can often be detected by the darker color and slight depression of the bark.

Adult beetles are about one-half inch long, flattened, and metallic in appearance. They lay their eggs in cracks in the bark, or in injured places on the sunny parts of the tree trunks. The larvae, or borers, are readily recognized by their large, flattened heads. The insect passes winter in the borer stage and pupates in spring. Development from egg to adult usually requires a year.

Control

The most effective way to prevent injury by these borers is to maintain vigorous trees by following approved practices of cultivation, fertilization, spraying, and conservation of soil moisture.

You can protect newly transplanted trees by wrapping the trunks from the ground to the lower limbs with newspaper, burlap, or crepe paper of double thickness, placing asphalt between the layers. Wind the wrapping spirally or vertically, and hold it in place with a light cord. Apply the wrapping soon after the leaves appear in spring and leave it in place as long as it is serviceable, provided the cord does not girdle the trees.

When trees are infested, remove the borers with a knife, cutting into the bark and wood as little as possible. Hold the knife blade flat against the tree and work along the course of the burrow; trim the edges later. Removing the bark and frass from the deeper part of the burrow

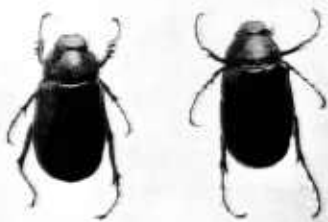
is believed to hasten healing of the wound. To keep the wood from drying until the bark heals over, paint the deeper parts with a pruning compound or with a mixture of one part of creosote and three parts of coal tar.

Examine young trees at least once a year, preferably in March or April before mature borers emerge. If the infestation is heavy, examine trees during summer for grubs overlooked.

MAY BEETLES

May beetles, or June bugs, sometimes defoliate pecan trees in spring. Small trees surrounded by uncultivated land are most subject to injury. The beetles feed at night; in the daytime they lie hidden just beneath the surface of the ground.

The adult beetles (fig. 20) are $\frac{1}{2}$ to $\frac{3}{4}$ inch long, robust, and usually brown. They lay their eggs in the ground, and the larvae, which are white grubs, feed on the roots of plants, particularly grasses. Larval development requires 2 years or more.



BN-3620

Figure 20.—May beetles.

Control

Since the grubs of May beetles feed in the soil, especially in sod land, they are seldom injurious in well-cultivated orchards that are some distance from uncultivated land. Fields near orchards are a source of infestation, but if the soil is plowed once a year, the May beetles are not likely to become very numerous.

Beetles on small trees may be shaken onto sheets on the ground at night and destroyed. On both small and large trees, control can be obtained by applying parathion, Guthion, EPN, or malathion, when the beetles are first noticed.

If infestation persists, two or three spray applications may be necessary. In each 100 gallons of water, mix 2 pounds of 15-percent parathion wettable powder or 2 pounds of 25-percent Guthion, EPN or malathion wettable powder. See Precautions, page 45.

RED-SHOULDERED SHOT-HOLE BORER

The red-shouldered shot-hole borer makes small exit holes in the bark of pecan trees. These holes give the trunk the appearance of having been hit by shot (fig. 21). The first signs of these borers in a tree are light sawdust particles coming from the holes. Injury caused by severe drought or cold weakens trees for borer attack. Several similar insect species work on weak trees; some of them feed only on the bark and in the cambium region; others go deep into the heartwood.



TC-4522

Figure 21.—Exit holes of adults of the red-shouldered shot-hole borer.

Control

To control the borers, keep trees in a healthy condition and as far as possible reduce sources of infestation, such as dead trees and prunings. Application of a quick-acting fertilizer often assists in restoring an individual tree if it is not too severely weakened.

CURCULIOS

Two species of curculio that attack pecan are *Conotrachelus pecanæ* and *aratus*; the latter is known as the hickory shoot curculio. They attack the unfolding buds and shoots on pecan late in March and in April in some areas of the Pecan Belt. Severe infestations occur most commonly on uncultivated trees and in cultivated orchards ad-

jacent to woodlands containing native pecan and hickory trees. Fifty percent or more of the shoots may become infested.

The larvae of *pecanæ* tunnel in the buds and tender shoots, and when present in large numbers may kill or weaken many nut-bearing shoots. Larvae of the hickory shoot curculio tunnel within the shoots and leaf stems near the point where the leaves are attached, causing premature loss of foliage and weakening the shoots.

A third species, *Conotrachelus hickoriae*, attacks immature pecan nuts during late June, July, and early August in some parts of Louisiana, Arkansas, and Mississippi. The larvae tunnel in the nuts before the shells harden, and cause them to drop. The injury is similar to that caused by the shuckworm. Damage appears to be light when the trees set a good crop of nuts.

Control

BHC and lindane have given fairly good control of *pecanæ*. Mix 4 pounds of BHC (10-percent gamma), or 1½ pounds of 25-percent lindane wettable powder in each 100 gallons of water. Apply when the buds show from ¼ to 1 inch of green growth or when jarring of the trees indicates that many adults are present. BHC has also been partially effective against *aratus* when applied shortly after the leaves begin to unfold or separate from the tender shoots. No tests have been conducted against *hickoriae*. See Precautions, page 45.

DISEASES OF THE PECAN

The pecan is affected by fungus, bacterial, and virus diseases and by environmental disorders of various kinds. Fungus diseases are caused by small, usually microscopic, plants. Bacterial diseases are caused by one-celled microscopic organisms. Virus diseases are caused by submicroscopic agents, the exact nature of which has not yet been determined. In contrast, the environmental disorders are caused by conditions such as a deficiency of one or more mineral elements (resulting in nutritional diseases), sudden changes in temperature, varying amounts of moisture, or other adverse nutritional or climatic factors.

Fungus diseases are by far the most numerous and widespread of the diseases that attack the pecan. For this reason they offer the most difficult problems in control. Bacterial and virus diseases are of much less importance. The environmental disorders may often be of considerable importance in certain localities, but because they are not infectious they are usually less serious in their effects and less difficult to control.

SCAB

Scab, a fungus disease, is very destructive to the pecan, especially in the Southeastern States and in the southern part of the Gulf Coast States. Its control is of major importance to the industry.

Scab attacks certain seedling trees and those of most grafted varieties. Most of the older varieties

that have been planted extensively are scabbing so badly that they produce poor-quality nuts or none at all in certain areas of high rainfall and high humidity. Even Stuart, one of the oldest and most widely planted varieties, is now severely affected in some areas of Mississippi. Moneymaker, Teche, and Curtis, varieties formerly considered immune, have now been found to be susceptible to scab in some localities. Scab on Curtis is confined mostly to young trees growing in nurseries. Newer varieties that have been less extensively planted, such as Desirable, Farley and Elliott, appear to be highly resistant. Nevertheless, it seems probable that all varieties and seedlings eventually will be found susceptible.

Scab fungus attacks the rapidly growing tissues of leaves, shoots, and nuts. When leaves and shoots stop growing they become somewhat resistant to infection, but the nuts remain susceptible until shortly before they mature. Vigorously growing trees of scab-susceptible varieties are therefore more severely affected than are those in a low state of vigor.

The greatest damage is done to the nuts, the loss sometimes being complete. On highly susceptible varieties—such as Schley, Teche, and most of the western varieties—defoliation often results, especially when frequent infections occur from early spring into the summer.

The scab fungus overwinters in the infected spots on old leaves and shucks or on the shoots of the trees.

When weather conditions become favorable in the spring, the fungus becomes active and produces spores. The spores are carried by water and air movements to new leaves, shoots, and nuts, where they may cause further infections (fig. 22).



BN-3602

Figure 22.—Scab infections (black spots) on leaflets of the Schley variety of pecan in early spring.

Infection of leaves, shoots, and nuts by the scab fungus occurs during cloudy, rainy periods of spring and early summer, when leaves remain wet for at least 12 hours. Under such favorable conditions, primary infections may occur before the middle of April and develop rapidly. Spores can germinate and cause infection within a few hours. It is generally 1 or 2 weeks, however, before scab lesions

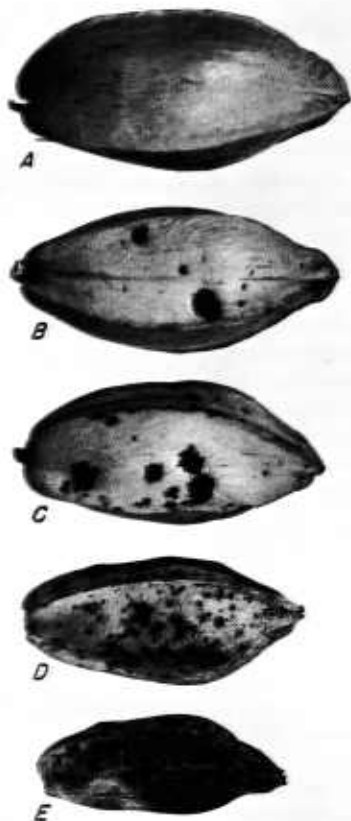
(diseased areas) can be observed on new tissue of either leaves or nuts. During damp periods new crops of spores are produced in unsprayed leaves by the last week of April or the first week in May. These spores cause secondary infections.

Primary infections first appear as elongated, olive-brown lesions, usually on the veins of the undersides of the leaves. At first the spots are the size of pin points. They soon enlarge and coalesce. Later, with the development of secondary infections, large areas of the leaves may become almost black. On the nuts, the spots of infection are small, black, and circular. At first they are slightly raised, but later they may become sunken. The nuts of highly susceptible varieties may be so extensively infected that practically the entire surface of the nut will appear black.

Scab injury on Schley nuts is illustrated in figure 23. Of the five classes of nuts shown, only those of class *E* are unmarketable. Nuts in classes *C* and *D* are poor in quality, however. Severely infected nuts may drop prematurely, or they may stop growing and remain attached to the shoots.

Control

To reduce scab infection, knock all old shucks and leaf stems off the trees before leaves begin to come out in the spring. If this is not done, infection of the foliage by rainwashed scab spores probably will occur. After a rain or on misty or foggy days, a slight jarring of branches will cause most of the old, wet shucks and leaf stems to fall.



BN-3603

Figure 23.—Nearly full-grown nuts of the Schley variety closed according to degree of scab infection: A, No infection; B, one to three primary infections; C, four or more primary infections; D, a few secondary infections; E, many secondary infections.

Wherever possible turn the shucks, leaf stems, and leaflets under with a plow, deep enough that they will not be turned up again by disk harrows or other cultivation machinery.

Where winter cover crops are planted—a practice followed in

most successful orchards—turning under shucks and leaves is not practicable. In such orchards it is imperative that the trees be thoroughly sprayed with a fungicide such as Bordeaux mixture, dodine,¹ or zineb, according to the general spray schedule on page 49.

Removal of low limbs will make it possible to plow near the trees. It also will let more sunlight through to the foliage and allow better air circulation; this will promote quicker drying of leaves and nuts after rains and heavy dews, and reduce chance of infection by fungus spores. Low limbs may be cut from the trees, or in mature orchards they may be pruned by allowing livestock to browse on them.

Of all the materials tested for control of scab, homemade low-lime Bordeaux mixture (p. 47), dodine, and zineb have given the best results. By applying these fungicides according to the schedule on page 49, scab can be controlled to the point where it will cause only slight or no injury.

Proper timing and thoroughness of the spray applications are important. Sometimes weather conditions are such that it is not possible to spray in time to prevent early infection on the young nuts. If later applications are properly applied to the trees, however, secondary infection can be prevented and nuts of good quality probably can be produced (fig. 24).

¹ The application of dodine injures the leaves of some varieties such as Moore and Van Deman; it should not be used on them.



BN-3604

Figure 24.—These nuts of the Schley variety were infected by scab early in the spring. Primary infections produced the black, sunken spots on the shucks. Secondary infection was prevented by three applications of Bordeaux mixture, the last about July 15. Nuts are shown as they appeared on October 1.

ROSETTE

Rosette is a nutritional disease caused by zinc deficiency. The disease occurs when there is not enough available zinc in the soil to meet the requirements for pecan tree growth and nut production.

Prior to the discovery in 1931 of the cause and control of rosette, most of the bearing pecan trees in the Southeastern States were affected by the disease. Since that time, the soils of most pecan orchards in that area have been treated with zinc sulfate. Once rosette is controlled in this way, it is a minor problem and only an occasional application of zinc sulfate is needed thereafter.

Rosette can occur under various soil conditions throughout the areas where pecans are grown. The disease causes serious damage both in native groves and in orchards of improved varieties.

The following soil conditions are most commonly associated with rosette: Lime-impregnated, sandy loam, loamy sand, and deep sandy soils deficient in organic matter; eroded soils with little or no surface soil remaining; and fertile soils that have been deeply and frequently cultivated or that have received too much fertilizer, especially nitrogen, or lime.

A high percentage of the trees in young orchards that are intercropped annually with cotton, corn, or peanuts are likely to be affected by rosette unless they are treated with zinc sulfate.

In its earliest stages, or on slightly affected trees, rosette appears as a yellowish mottling of the leaves, particularly in the treetops. In its advanced stages, the leaflets are slightly narrowed and crinkled. When the trees are severely affected, the leaflets are extremely narrowed and have reddish brown areas or perforations between the veins. New shoot growth is checked, the internodes are shortened, and the foliage is therefore bunched, or rosetted, in appearance. The name of the disease is derived from this characteristic.

In the final stages of the disease, the shoots die back from the tips. Usually the die-back is confined to the current year's growth, but sometimes it extends to older branches of considerable size. Seriously affected trees rarely bear nuts, and nuts that are borne are usually small and poorly filled.

Foliage on badly rosetted trees develops earlier in spring than that on healthy trees, probably because

of the pruning effects of the die-back. Symptoms of the disease on moderately or severely affected trees become more pronounced as the season advances, and by October or November the trees appear at their worst. At this time the foliage of seriously diseased trees has a rusty or bronzed appearance, especially when viewed from a distance.

Control

To correct the condition that causes rosette, apply zinc sulfate in solution as a spray to the trees or as a dry salt on the soil. Trees recover most rapidly from the effects of rosette when they are sprayed, but soil applications are to be recommended because of their lasting effect.

For mild cases of rosette, make 3 spray applications to the trees. Spray with a solution consisting of 2 pounds of zinc sulfate, analyzing approximately 36 percent zinc, in 100 gallons of water. Make the first application as soon after pollination as possible and the other two at intervals of 2 to 3 weeks. This treatment must be repeated annually until all signs of the disease have been eliminated. Thereafter, the trees should be closely observed for indications of the disease, since it is likely to reappear at any time.

To control scab and other parasitic disease at the same time rosette is treated, dodine, zineb or Bordeaux mixture can be combined with zinc sulfate. Increase the proportion of zinc sulfate (use 4 pounds per 100 gallons of Bordeaux mixture), because the lime in the

Bordeaux mixture reduces the effectiveness of the zinc. To check the corrosive action of the zinc sulfate on your equipment, rinse the spray pump and tank thoroughly after each day's spraying.

Applications of zinc sulfate to the soil may be somewhat more expensive than spraying because the chemical is often applied at higher rates. Soil applications give more lasting control of rosette, however. Applications are usually effective and relatively inexpensive on acid, neutral, and light-textured alkaline soils. On heavy-textured alkaline soils or on soils that have a high fixing power for zinc, extremely high rates of application are usually necessary, and spraying is generally preferable.

Zinc sulfate is applied to the soil in the same manner as fertilizers. If necessary, it can be mixed with a fertilizer. On soils that do not have a high-fixing power for zinc, or when trees are not severely rosetted, apply zinc sulfate at an annual rate of 5 pounds per tree. Severely rosetted trees require between 5 and 10 pounds of zinc sulfate annually for 2 or more years (figs. 25 and 26). The larger the dosage the first year, the greater will be the improvement from the diseased condition.

Make applications in late February or early March by broadcasting the zinc sulfate evenly beneath the trees, from near the trunk to beyond the radius of the limbs. To insure quick and positive incorporation, disk or plow the zinc sulfate into the soil, especially under the following conditions: On steep slopes that



BN-3630

Figure 25.—Pecan tree seriously affected with rosette. Dead branches can be seen at top of the tree. Leaflets on other branches are small, narrowed, curled, and yellowish green. Figure 26 shows the same tree after treatment with zinc sulfate.

may wash; on alkaline soils where the zinc may be fixed in the surface soil; or when there is not enough moisture to dissolve the material and carry it down into contact with the absorbing roots. If you grow a winter cover crop in your orchard, distribute the zinc sulfate evenly and in small amounts to avoid burning the crop; delay cultivation if the chemical is applied in February or March as recommended.

DOWNY SPOT

Downy spot is a fungus disease that affects the leaves of pecans. It occurs throughout the southern pecan-producing region. The disease usually appears first in late spring or early summer as downy or "frosty" spots on the lower sides of the leaflets (fig. 27). This appearance is due to production of spores by the fungus. Later, after



BN-3624

Figure 26.—The tree shown in figure 25 as it appeared 2 years later, after rosette had been controlled by yearly broadcast applications of zinc sulfate to the soil.

these spores have been washed away or have deteriorated, greenish-yellow spots about one-eighth inch in diameter remain on both sides of the leaves. These spots are clearly visible. As the season advances, the color of the diseased parts changes to brown. These parts of the leaves die, and the result is a premature defoliation of the trees.

The fungus that causes downy spot lives over winter in the diseased leaves, where its life cycle is completed. In early spring, espe-

cially during rainy periods, the new leaves are infected by the large number of spores expelled from the fruiting bodies in the old leaves.

All pecan varieties are attacked to some extent by the downy spot fungus, but Burkett, Moneymaker and Stuart are among the most susceptible.

Control

To reduce infections of new leaves by downy spot, plow under old diseased leaves in spring before tree growth begins and before the fruit-

ing bodies release their spores. Spraying trees according to the general spray schedule (p. 49), will control downy spot and other diseases, particularly scab.

VEIN SPOT

Vein spot is a fungus disease that attacks pecan leaves. It is prevalent in the southwestern part of the Pecan Belt, including the States of Arkansas, Louisiana, Mississippi, Oklahoma, and Texas.

The resemblance of the lesions of vein spot to those caused by scab on the leaves is so close that one disease may easily be mistaken for the other. The spots characterizing each disease may originate on the veins of leaflets or on leaf stems (rachises) and are dark brown or black in the final stages. On lateral veins, lesions caused by vein spot are circular or oval and seldom attain a diameter of more than one-fourth inch; on midribs of leaflets and on leaf stems, spots are long and narrow. On midribs, spots sometimes extend from the base to the apex of the leaflet. Unlike scab, vein spot does not attack the shoots or nuts, and the fungus apparently invades tissues of leaflets only a short distance on each side of the veins (fig. 28).

Because vein spot fungus attacks and kills the growing tissues of leaves, premature defoliation often follows moderate to severe infections. If leaf stems are severely affected, the leaflets, and frequently entire leaves, drop prematurely. If leaflet stems (petioles) become girdled and die, leaflets may hang on the tree for a time.

The life history of the vein spot fungus is similar to that of most other fungi known to infect pecan leaves. It lives through the winter on fallen leaves. During early spring, spores are formed; they are



BN-3606

Figure 27.—Characteristic white or "frosty" spots on the underside of a pecan leaflet caused by the downy spot disease in its early stages.

discharged into the air and infect new leaves.

and stems that are likely to carry the vein spot fungus. To control the disease with fungicides, spray the trees once before pollination with 4-1-100 Bordeaux mixture and once or twice after pollination with zineb or 6-2-100 Bordeaux mixture. Make the second application as soon after pollination as possible; make the third 3 to 4 weeks later. (See spray schedule, p. 49.)

LEAF BLOTCH

Leaf blotch is a fungus disease of nursery and mature trees; it is present throughout most of the pecan-growing region. It is first indicated by the appearance of olive-green, velvety tufts in June or July (fig. 29). Yellow spots appear later on the upper surfaces of the leaves. Fruiting bodies, black pimplelike structures, make their appearance about midsummer. After the spores have been washed away by rain or have otherwise deteriorated, groups of these pimplelike structures unite, giving the leaves a black, shiny, blotched appearance. Occasionally these blotches join to envelop entire leaflets, causing premature defoliation of the tree.

The organism that causes leaf blotch is a weak parasite and does not attack orchard trees unless they have been lowered in vigor by overcrowding, rosette, attacks by borers, or general neglect. Nursery trees are more susceptible, and the disease is especially prevalent where nursery blight is present. When trees are infected with leaf blotch, defoliation begins with the basal



BN-3605

Figure 28.—Vein spot disease on a pecan leaflet. Spots are dark brown or black in the final stages of the disease.

Control

Use good sanitation practices and, where possible, plow under leaves



BN-3807

Figure 29.—Early stage of leaf blotch on the underside of a leaflet. The pimplelike fruiting bodies have just begun to form dark blotches.

leaves. The disease gradually progresses upward until defoliation is complete except for a few leaves in the tops of the trees.

Control

Plow under old leaves in early spring to insure as high a degree of cultural control of the leaf blotch

fungus as possible. Chemical control measures used against scab and downy spot are also effective in controlling leaf blotch. Application of dodine, zineb, or a 6-2-100 Bordeaux mixture will prevent the development of the disease. (See spray schedule, p. 49.) In localities where only leaf blotch is present, spray the trees two or three times (first, second, and third cover sprays) with either of these fungicides. Apply the first spray soon after pollination takes place, and the second and third after intervals of 3 or 4 weeks.

BROWN LEAF SPOT

Brown leaf spot is a fungus disease of minor importance, especially on healthy trees. Although it is found throughout the Pecan Belt, it causes serious premature defoliation only in localities where there is heavy rainfall or on trees that lack vigor because of neglect.

Brown leaf spot first appears in June or July and is found only on the mature leaves. Primary infections are circular in outline (fig. 30) and are reddish brown; they often develop grayish concentric zones. As the disease progresses, the spots become irregular in outline. If not controlled, the disease may cause complete defoliation by the first of October. Like other leaf fungi, the brown leaf spot organism is carried over winter in the infected spots on old leaves.

Control

To control brown leaf spot, spray trees one or more times between

May 15 and June 15 with dodine, zineb, or 6-2-100 Bordeaux mixture. (See spray schedule, p. 49).

LIVER SPOT

In some years, a fungus disease known as liver spot causes considerable damage to pecan foliage in Mississippi, Louisiana, Arkansas, and Texas. Evidence of this disease first appears in May or June as dark-brown circular spots on the lower surfaces of the leaflets, mainly along each side of the midrib (fig. 31). Spots are usually $\frac{1}{8}$ to



BN-3608

Figure 30.—Brown leaf spot on the underside of a leaflet. The diseased spots are often characterized by concentric markings (not visible in photograph).



BN-3609

Figure 31.—Early stages of liver spot on a pecan leaflet.

$\frac{3}{8}$ inch in diameter. In September and October, the color of the spots changes to a cinnamon brown, and at about the same time, small, dark, spore-bearing bodies appear in the center of the spots. Leaflets that have several spots will fall during September or October. If spring weather is damp and favorable for numerous infections, severe premature defoliation may occur.

The fungus that causes liver spot survives winter in a semidormant condition on fallen leaves. Upon return of moist, warm weather in spring, the fungus produces spores, which infect the new leaves.

The foliage of strong, vigorous trees is noticeably more resistant to attack than that of trees whose vigor has been impaired by the keen competition of weeds and grasses for moisture and plant nutrients.

Control

Liver spot can be controlled by the application of zineb, or 6-2-100 Bordeaux mixture. The first application should be made at the time of the first cover spray. This should be followed by the second and third cover spray applications. (See spray schedule, p. 49).

CROWN GALL

Crown gall is a bacterial disease that often causes damage to pecan trees. It was formerly believed that it affected only nursery trees (fig. 32), but in recent years the disease has been found well established in orchards—especially on old trees, which it may affect severely enough to kill (fig. 33).



BN-3610

Figure 32.—Crown gall disease on nursery stock. Trees so infected should be burned to prevent further spread of the disease.



BN-3611

Figure 33.—This 20-year-old pecan tree has been completely girdled by a large, wartlike growth caused by crown gall.

On mature trees, the disease is confined mostly to the large roots and bases of the trunks, but occasionally smaller roots are also infected. Wartlike growths from a few inches to a foot or more in

diameter, often extending several inches above the soil surface, characterize the orchard-tree development of the crown gall disease. Because of the fragility of the galls, they are often broken off from the roots. The galls may then become scattered on top of the soil when the orchard is being cultivated, thus spreading the disease organism.

Control

All nursery trees infected with crown gall should be destroyed by burning, preferably at the time of digging. Only disease-free trees should be planted in new orchards. There is no effective and practical control for crown gall on established trees. Do not cultivate the soil near the trunks of infected trees; the practice may spread the disease.

BUNCH DISEASE

The characteristic symptom of bunch disease is a bushy growth of slender, willowy shoots that result from an abnormal forcing of lateral buds into growth. Bunch disease appears to be infectious, and is known to spread from tree to tree. Apparently no parasite is associated with the abnormal growth. In some respects symptoms resemble those of some virus diseases of other woody plants such as peach yellows and bunch disease of walnuts.

In trees lightly affected with bunch disease, only portions of one branch or of several scattered branches will show the characteristic symptom. The bunch growths are most conspicuous in spring and early summer because their develop-

ment is earlier and greater than that of unaffected branches (fig. 34).

Seriously affected trees become mere skeletons of main lateral branches covered with a thick, broomy, sucker growth. On such trees, many leaflets die and fall in late summer or early fall; some shoots and branches also die, and few if any nuts are produced.

Bunch disease spreads slowly through a tree. Several years may be required for all of a large branch to become diseased after the first evidence of infection appears. Bunchy growths may arise from the base of a tree or at a graft union, but similar growths may not appear elsewhere on the tree for several years.

Bunch disease may easily be confused with rosette. Two differences can be noted on leaflets, however. Those affected by bunch disease do not become yellow between the veins, nor do they become extremely crinkled as do leaflets affected by rosette.

Bunch disease has been observed on water hickory and commercial pecan varieties as well as on wild trees. Different varieties show some difference in susceptibility to bunch disease.

The geographic range of bunch disease appears to be limited to areas having rich, alluvial soils in parts of Arkansas, Louisiana, Mississippi, Oklahoma, Texas, and New Mexico.

Control

No measures are known that will definitely control bunch disease. Never use bud or scion wood from diseased trees for propagation. It



BN-3612

Figure 34.—Effects of bunch disease on a pecan tree in early spring. Diseased branches often put out leaves about 2 weeks earlier than healthy branches.

is imperative also to use only disease-free pecan or water hickory trees as stocks in top-working native trees to standard varieties. Destroy any diseased pecan or hickory trees that may be growing wild in the vicinity of your orchard. On lightly affected trees, you may be able to arrest the disease by prun-

ing out diseased branches. Make the cuts well back from infected parts. Once a lateral branch is affected as far back as the trunk or a main limb of a tree, there is little hope of arresting the disease. Trees so affected should be destroyed immediately. The more susceptible varieties, such as Schley, Mahan

and Desirable, should not be propagated in locations where bunch disease is prevalent.

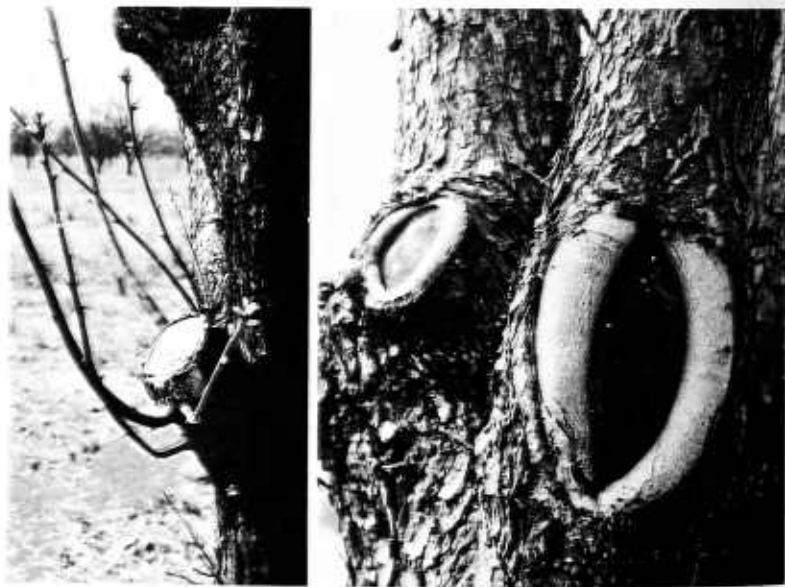
WOOD ROT

Broken branches or other wounds on pecan trees provide possible points of entrance for wood-rotting fungi unless the injured surfaces are properly treated. Once these fungi gain entrance, they spread rapidly through the wood and may destroy the entire tree.

Control

Cut off broken branches or limbs flush with the main branches or trunk of the tree (fig. 35). Do not leave projecting stubs; they rarely

heal over and thus continue to provide entrances for wood-rotting fungi. Smooth wounds heal more quickly than do those that have rough or jagged surfaces. Paint the wounds with a mixture of one part of creosote to three parts of coal tar to protect the surfaces; repeat this treatment once a year until the wounds have healed. This mixture is caustic and will slightly injure the cambium (growing layer), but the wounds will usually remain free of wood-rotting fungi, and eventually will heal. Commercial paints for tree wounds, having asphalt, tar, or vegetable gums as their base, may also be used to cover wounds.



BN-3813

Figure 35.—Tree at left has been improperly pruned. Wounds of this type heal slowly and provide entrances for wood-rotting fungi. Tree at right has been pruned properly and has healed rapidly; cuts were made flush with trunk and treated with the recommended mixture of coal tar and creosote.

COTTON ROOT ROT

Cotton root rot is a disease caused by a soil-inhabiting fungus. The disease has been found in Texas and other States westward to the Pacific coast. Although cotton root rot most commonly attacks cotton and alfalfa, it is harmful to many other plants. It has killed pecan trees in both Arizona and Texas.

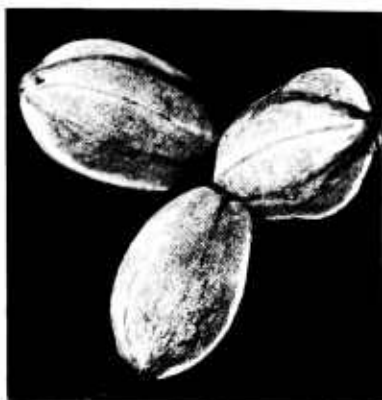
The fungus is most active during the summer. Injury to the roots reduces the moisture and mineral supply to the tree tops, which causes the death of trees. Some trees continue to live through one or two seasons, however, after symptoms of the disease become apparent. In such cases, the leaves may be yellow and sparse.

There is no practical means of controlling cotton root rot. It is suggested that growers avoid planting pecan trees in soil known to be infected with this fungus, especially where cotton or alfalfa has been killed by it.

POWDERY MILDEW

Powdery mildew usually is considered to be of minor importance on the pecan, although it occasionally causes serious damage to the nuts. This fungus disease affects both foliage and nuts; it forms white superficial growth (fig. 36) early in the growing season, usually in July. Premature defoliation of the trees occurs when conditions are especially favorable for the spread and development of the fungus. When the nuts are infected early in the growing season, those that develop may be small, the shucks may split prematurely, and the kernels

may be shriveled. During the winter the fungus remains dormant on infected leaves and shucks.



BN-3614

Figure 36.—Early stages of powdery mildew on pecan nuts of the Farley variety. The characteristic white growth has covered most of the surface of the nuts.

Control

To reduce infections caused by powdery mildew, plow under old leaves and shucks in spring before spores are released. Control of the disease with fungicides is relatively easy if spraying is done at the right time. Spray trees twice with zineb, or 6-2-100 Bordeaux mixture. Apply as the third and fourth cover sprays with an interval of 3 to 4 weeks between applications. (See spray schedule, p. 49.)

NURSERY BLIGHT

Seedling trees that are severely affected by nursery blight make little growth and are often too small for budding at the end of the second season. As its name implies, this disease is confined almost entirely to nursery trees.

The fungus that causes nursery blight invades both young and old leaflets. Infections begin in April, developing into small reddish lesions on both surfaces (fig. 37). Later in the growing season, the spots on the upper surfaces turn gray. Single lesions are usually about one-eighth inch in diameter. These spots may be united by secondary infections to form a continuous lesion along each side of a vein. Secondary, or late, infections are most numerous along the midribs and larger veins. The diseased areas soon are killed by the invading fungus, and the tissues become brittle and break. The affected

leaflets then have ragged margins and perforations.

Control

For control of nursery blight, spray the trees once with 4-1-100 Bordeaux mixture when the first leaves that form are half grown. Follow this spray application with three applications of zineb, or 6-2-100 Bordeaux mixture at intervals of 3 to 4 weeks. (See spray schedule, p. 49.)

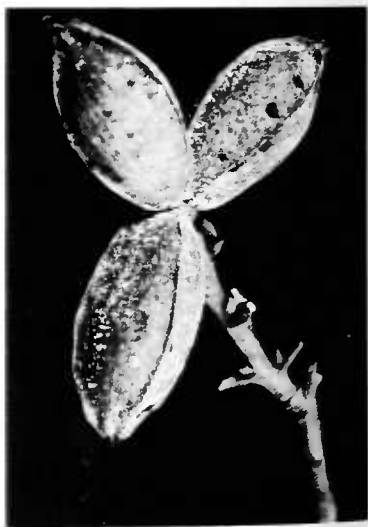
PINK MOLD

During late summer and early fall, a pinkish fungus growth known as pink mold can frequently be observed on the shucks of nuts that have been attacked by scab (fig. 38). The pink mold fungus invades the shucks mostly through the scab spots. It continues to de-



BN-3626

Figure 37.—Early stages of nursery blight on a pecan leaflet.



BN-3616

Figure 38.—Nuts of the Schley variety affected with pink mold. Scab lesions are visible on the nut at the upper right.

velop after the nuts have matured. The fungus may enter the inside of the nuts and attack the kernels. There it causes a decay known as "pink rot." Nut kernels affected with pink rot leak oil and often give off a strong, rancid odor. The shells usually have an oily appearance.

Nuts of the Schley variety, particularly those grown on unsprayed trees, are often seriously affected by pink mold. Only a part of the crop may be marketable if many of the nuts have been infected.

Control

Pink mold attacks chiefly scab-infected nuts, and only when these nuts are still on the trees. After harvest, the mold does not spread from infected to sound nuts. To insure control of the disease, follow the spray program for the control of scab described on page 49.

LICHENS

Lichens frequently occur on the trunks and branches of pecan trees, usually in the humid climate of the gulf coast. These growths give the trees an unkempt appearance but are usually considered to be harmless.

Lichens are low forms of plant life that grow in humid localities. They are not single plants but are composite organisms made up of algae in enveloping meshes of fungus filaments. Like mosses, lichens obtain their food chiefly from air and water, and they attach themselves not only to trees (trunks, branches, and occasionally leaves) but also to such objects as fence-posts and rocks.

A common form of lichen is the grayish green, paperlike growth that occurs on the bark of pecan trees (fig. 39). This irregularly shaped growth varies from nearly an inch to several inches across. Its edges are usually lobed and curled upward.



BN-3631

Figure 39.—Lichens on bark of pecan tree branch.

Control

Because lichens are usually considered to be harmless to pecan trees, no spray program has been worked out for their control. However, almost any standard fungicide, including Bordeaux mixture, and solutions containing organic coppers, will readily control lichens. Lichen growths are never found on trees that are sprayed regularly with Bordeaux mixture for the control of scab and other pecan diseases.

SPANISH-MOSS

The common gray moss, or Spanish-moss (*Tillandsia usneoides*), occasionally becomes unsightly and injurious on pecan trees. It is usually most troublesome in neglected orchards located in areas having poor air movement and high humidity, especially when live oak trees are growing nearby. Spanish-moss is not a true moss, but an epiphytic plant—one that has no true roots. Its nourishment is derived from the air, rain, and dew. It grows not only on trees but also on many in-

animate objects. Large accumulations of Spanish-moss are detrimental to tree vigor and growth because of their shading effects (fig. 40.)

Control

Spanish-moss needs sunlight for heavy growth. To keep it in check, therefore, make sure orchard trees are vigorous so they will provide maximum shade. An efficient cultural and fertility program usually will invigorate trees enough to keep the moss in check. Spray trees with a mixture of 10 pounds



Figure 40.—Accumulation of Spanish-moss on a pecan tree.

BN-3617

of copper sulfate and 10 pounds of calcium arsenate in each 100 gallons of water. Spray them annually while they are dormant, preferably in February or March. Three

annual applications are usually sufficient to eliminate moderate infestations. Do not allow livestock to graze in orchards for 2 weeks after spraying with calcium arsenate.

INJURY CAUSED BY CLIMATIC CONDITIONS

WINTER INJURY

Winter injury is a disorder usually found on young, vigorous, late-growing pecan trees. It also occurs on trees that have prematurely lost their leaves and then have put out new leaves late in the growing season. If such trees have not become dormant before freezing weather, their growing tissue is likely to be injured, particularly near the base of the trunk. During the next spring, severely affected trees usually leaf out and appear to grow normally. However, as soon as hot weather begins, the leaves wither and the trees suddenly die.

Winter injury is easily detected. The bark on the injured area appears sunken and is cracked where it meets the growing tissue, which is discolored and sour smelling. The roots of affected trees seldom die, but sprout from below the dead trunks. Shothole borers and other insects are sometimes present, but their damage is of a secondary nature.

Proper cultivation, fertilization, and spraying do much to prevent winter injury. Cultivation should not ordinarily be continued later than midsummer. However, an orchard may be cultivated as part of the planting of winter cover crops in fall, when trees are ap-

proaching dormancy. The trees should be fertilized only in early spring. Spraying to control diseases and leaf-destroying insects should be done at the proper time. If these practices are followed, trees will have a good chance of escaping premature defoliation and of going into winter in a mature and hardy condition.

SUNSCALD

Injury from sunscald is sometimes confused with winter injury. The symptoms are dead or cankerous areas, usually on the southwest side of the trunk or on the upper surfaces of large branches. Like winter injury, sunscald occurs mostly on young trees, but it also occurs on older ones that have been cut back for topworking to some other variety.

Bright sunshine, which raises the temperature of unshaded bark to the killing point, is probably the sole cause of sunscald in summer. During winter, the condition probably is caused by the combined effect of bright sunshine and a sudden, usually severe, drop in temperature at the end of the day. The dead areas below the bark furnish ideal points of entrance for borers and other insects and for wood-rotting fungi.

One of the best methods of preventing injury from sunscald is to head the young trees low so that the branches will shade the trunk. Because the lower limbs give protective shading to the trunks of young trees, they should not be trimmed off until the trees have made several year's growth. Wrapping the trunks of young trees with gunny sacks or paper, or whitewashing them, will also aid in preventing sunscald.

LIGHTNING INJURY

Lightning strikes young and mature pecan trees causing injury or

even death to them. Such injury is often mistaken for the effect of some parasitic disease.

When a pecan tree is struck by lightning, the principal visible injury may be confined either to the limbs and branches or to the trunk. There may be a narrow split in the bark, extending from a branch in the top down the trunk to the ground, or the bark may be completely peeled from the trunk, especially near the ground. If the bark is only split, the tree usually survives; if the bark is loosened or peeled from the trunk, the tree dies within a few weeks.



Figure 41.—The bark of the trunk of this tree was split to the ground by lightning. Some of the branches died in about 4 weeks, but the rest of the tree later recovered.



BN-3619

Figure 42.—Pecan tree killed by lightning, shown as it appeared 3 months after having been struck. Note how the bark was stripped from trunk.

Trees struck by lightning usually undergo partial to complete defoliation, depending on the extent of

the injury. Leaves of affected areas first turn yellow and later drop. A tree can become completely defoliated within 30 to 60 days after being struck. Apparently, definite signs of lightning injury are confined to the trees that receive direct hits.

There is no practical way to prevent damage from lightning in an orchard, but trees killed or injured by lightning should be treated promptly. If a tree is killed, it should be destroyed; otherwise it may become infested with borers that probably will spread to other trees. Dead limbs should be removed. Wounds left after such pruning should be painted with a mixture of coal tar and creosote as recommended for the control of wood rot. Spraying injured trees with 4 pounds of 50-percent DDT wettable powder in each 100 gallons of water, will aid in preventing infestation by borers. Also, wounds and cracks in the bark should be painted with neutral asphalt or a pruning compound to prevent rapid drying and borer infestation. If injured trees are properly cared for, most of them eventually recover.

INSECTICIDES AND FUNGICIDES

PRECAUTIONS

Insecticides and some fungicides are poisonous. Handle them with care. Follow the directions and precautions for use and safe handling given on the labels on containers. Store insecticides and fungicides in plainly marked containers away from all food prod-

ucts, in a dry place where children and domestic animals cannot reach them. When mixing and applying them, take care to keep the materials out of the mouth and eyes and away from the tender parts of the body. Wash the face and hands thoroughly after applying any insecticide. After long exposure, take

a bath and change clothing. Wash clothing on which spray residues have accumulated before wearing it again.

If overexposure to insecticide results in ill effects, consult a physician immediately. If you swallow an insecticide or fungicide, induce vomiting immediately. Then call your physician, lie down, and keep quiet. If your physician needs information concerning symptoms and treatment of actual or suspected poisoning by a pesticide, have him call his nearest poison control center or the U.S. Public Health Service at its nearest office.

Empty containers are hazardous. Empty bags and packages should either be burned in the open or buried; metal containers should be crushed and buried. Avoid breathing dusts or vapors when crushing empty bags, packages or metal containers.

To protect wildlife, do not contaminate streams, lakes, or ponds with pesticide chemicals.

Do not allow dairy cows or animals being finished for slaughter to feed on vegetation under trees that have been treated with insecticide. Remove grazing animals from orchards during spraying and keep them out until residues decline to a safe level. This will be about 2 weeks if phosphorus insecticides other than parathion have been applied, and considerably longer (exact time not known) if chlorinated hydrocarbon insecticides have been used.

Insecticides such as demeton, EPN, Guthion, parathion, TEPP, and Trithion are extremely poison-

ous and may be fatal if swallowed, inhaled, or absorbed through the skin. Do not use them in small home plantings. They should be used only by a person thoroughly familiar with their hazards and who will assume full responsibility for safe use and comply with all the precautions on the labels. Handle them only in the open air or in a well-ventilated room.

Do not use TEPP later than 3 days before harvest, demeton and EPN later than 21 days before harvest, or Guthion, parathion, and Trithion after the shucks begin to open.

INSECTICIDES

BHC, DDT, dinitro insecticides, lindane, malathion and toxaphene are insecticides that can be handled safely as recommended for controlling pecan insects by following the precautions on container labels. Do not use dinitro insecticides after the buds begin to swell; do not use BHC or lindane after the nuts are present. DDT, malathion, and toxaphene can be used at any time, as needed, before the shucks split.

Oil sprays can be used as needed, since they are exempt from a tolerance. Pecan trees are less tolerant of dormant oil sprays than are many kinds of deciduous tree fruits. It is important, therefore, to follow directions carefully to obtain the recommended quantity of oil in the dilute spray. Do not apply an oil spray when temperatures are below 50° F. or over 90°. Use an oil of near 100 seconds Saybolt viscosity for dormant treatments; use a highly refined oil of nearly 70 seconds Saybolt viscosity and with an

unsulfonated residue of at least 85 to 90 percent for summer treatments.

FUNGICIDES

Bordeaux mixture.—A 6-2-100 formula for Bordeaux mixture requires 6 pounds of powdered copper sulfate and 2 pounds of hydrated lime in enough water to make 100 gallons of spray material. Smaller or larger quantities of the same formula can be made by changing the amounts of each ingredient in proportion.

To make 500 gallons of 6-2-100 Bordeaux mixture use the following procedure: Weigh out 30 pounds of powdered copper sulfate and 10 pounds of hydrated lime. Add about 10 gallons of water to the lime in a separate container to make a slurry. The copper sulfate may be dissolved by placing it in the strainer of the sprayer tank while the tank is being filled with water. When the tank is about three-fourths full and all the copper sulfate is dissolved, add the lime slurry slowly. The agitator should be running so that the lime will be thoroughly mixed with the copper sulfate solution. After the lime slurry is added, finish filling the tank with water. Bordeaux mixture is exempt from tolerances.

Bordeaux mixture can be combined with insecticides, except toxaphene, without loss of its effectiveness. It is therefore possible to spray against insects and diseases in the same operation.

Dodine.—Dodine² is the coined name for the chemical n-Dedecylguanidine acetate, which is the active fungicidal agent. It is form-

ulated as a 65-percent dry wettable powder. Dodine is widely compatible with a large variety of other spray materials and insecticides. It is not compatible with lime or other alkaline products. Limited use on pecan has resulted in superior control of pecan scab on most varieties. On some varieties, such as Moore and Van Deman, dodine has caused severe injury and should not be applied.

Dodine should be used at the rate of 0.5 to 1.0 pound of the 65-percent wettable powder in each 100 gallons of water; strength of the mixture should depend on the season and the severity of the scab situation. The dry, wettable powder should be added directly to the spray tank, when the tank is half full and the agitator is running.

There is no tolerance for dodine on pecan. Do not apply more than 700 gallons of diluted spray material per acre of orchard per application. Do not apply dodine after the shucks have started to split.

Zineb.—Zineb³ formulations containing the effective fungicidal chemical, zinc ethylene bisdithiocarbamate, are available as 65-percent, dry, wettable powders. These fungicides are compatible with all the recommended insecticides. The 65-percent material usually is applied at the concentration of 2 pounds of packaged material in each 100 gallons of water.

² Dodine is available under the trade name or designation Cyprex 65W.

³ Zineb formulations are available under the trade names Dithane Z-78, Parzate, and others.

To make 500 gallons of spray material, use 10 pounds of a zineb formulation. Place the material in a container and add enough water to make a paste. Add water to the paste until it becomes a slurry (thin, watery mixture). As the spray tank is nearly filled with water, and the agitator is running, add the slurry. Delaying the addition of the slurry will permit a more nearly complete suspension of the zinc salts in the water. Insoluble zinc salts are heavy and soon settle to the bottom of the tank unless the mixture is constantly agitated while spraying is underway. One quart of summer-oil emulsion added to each 100 gallons will give the spray material good sticking quality. There is no residue tolerance for zineb on pecans. Do not apply zineb later than 45 days before harvest.

SPRAY MACHINES

New types of spray machines depend on a strong blast of air to carry the spray through the trees. Some are designed to apply spray materials in a more concentrated form than commonly used. Only the most powerful machines of this type are suitable for treating orchards that have large trees. Portable spray outfits are commonly used for treating pecan trees. They are either equipped with 15- to 35-horsepower motors or driven by

power takeoff on tractors or trucks. The sprayer tank should hold at least 400 to 500 gallons. The machine should have a pump capacity of 20 gallons or more per minute and maintain a pressure of 400 to 600 pounds per square inch with the spray gun open. Trees from 40 to 60 feet high can be sprayed with machines of this type.

The operator must be prepared to spray parts of the trees at close range and other parts at comparatively long distances. Therefore, a spray gun equipped with a number 12 or 14 disk that can be adjusted to produce either a wide-angled mist or a narrow, driving spray is preferable. Tree tops can be sprayed most thoroughly by standing on top of the spray machine or in a tower attached to the top of the machine. A high-pressure hose three-fourths inch in inside diameter is best.

A grower who has a small orchard of young trees may use a smaller machine than the ones described. If possible, sprayers should be purchased from a dealer who carries a supply of parts and equipment for needed replacements.

Airplane applications of concentrated spray materials have been used effectively for controlling aphids, mites, some leaf feeding insects, and the pecan leaf casebearer. They have not been entirely satisfactory for controlling the pecan nut casebearer, hickory shuckworm, pecan weevil, or pecan diseases.

Spray schedule for control of pecan insects and diseases

Spray, and time of application	Insect or disease to be controlled	Spray material, and amount to mix in 100 gallons of water	Remarks
First prepollination spray, when buds are bursting and first leaves are showing.	Scab or downy spot.....	4-1-100 Bordeaux mixture or 65-percent dodine, 0.5 pound.	To prevent foliage injury, apply only when temperature is above 55° F.
Second prepollination spray, when first leaves are half grown.	Scab, downy spot, vein spot, liver spot, or nursery blight.	4-1-100 Bordeaux mixture or 65-percent dodine, 0.5 pound.	
	Pecan leaf casebearer.....	15-percent parathion 2 pounds or 25-percent malathion, 3 pounds.	
First cover spray, when tips of small nuts have turned brown.	Scab, downy spot, vein spot, leaf blotch, brown leaf spot, liver spot, or nursery blight.	6-2-100 Bordeaux mixture or 65-percent dodine, 1 pound or 65-percent zineb, 2 pounds plus 1 quart summer-oil emulsion.	
	Pecan nut casebearer, pecan leaf casebearer, aphids, or mites.	50-percent DDT, 2 or 3 pounds or 15-percent parathion, 2 pounds or 25-percent EPN, 2 pounds or 25-percent Guthion, 2 pounds.	Use the smaller quantity of DDT in the Southeast, and the larger quantity elsewhere. If pecan nut casebearer infestations are heavy, make a second application 1 week later with any of the insecticides listed. Use parathion if aphids and mites require treatment. Two-percent parathion dust at 50 pounds per acre, or 10-percent malathion dust at 40 pounds per acre may also be used.
	Rosette.....	4 pounds zinc sulfate in Bordeaux mixture.	Reduce zinc sulfate to 2 pounds if Bordeaux mixture is not used.

Spray schedule for control of pecan insects and diseases—Continued

Spray, and time of application	Insect or disease to be controlled	Spray material, and amount to mix in 100 gallons of water	Remarks
Second cover spray, 2 to 3 weeks after first cover spray.	Scab, downy spot, vein spot, leaf blotch, brown leaf spot, liver spot, nursery blight, powdery mildew.	6-2-100 Bordeaux mixture or 65-percent dodine, 1 pound or 65-percent zineb, 2 pounds plus 1 quart summer-oil emulsion.	If fall webworms or caterpillars are abundant, add 2 pounds of 50-percent DDT, or 15-percent parathion, or 25-percent EPN, or 25-percent Guthion, or add 3 pounds of 25-percent malathion in each 100 gallons. If sufficient aphids or mites are present to require control, use insecticides recommended on pp.9, 10, and 20.
	Rosette -----	Zinc sulfate, 4 pounds in Bordeaux mixture.	Reduce zinc sulfate to 2 pounds if Bordeaux mixture is not used.
Third cover spray, 2 to 3 weeks after second cover spray.	Scab leaf blotch, brown leaf spot, liver spot, nursery blight, powdery mildew.	6-2-100 Bordeaux mixture or 65-percent dodine, 1 pound or 65-percent zineb, 2 pounds plus 1 quart summer-oil emulsion.	If sufficient aphids or mites are present to require control, use insecticides recommended on pp. 9, 10, and 20.
	Pecan leaf casebearer, aphids, and mites.	50-percent DDT, 2 pounds or 15-percent parathion, 2 pounds or 25-percent Guthion, 2 pounds or 25-percent EPN, 2 pounds.	
	Rosette -----	Zinc sulfate, 4 pounds-----	Reduce zinc sulfate to 2 pounds if Bordeaux mixture is not used.

Fourth cover spray, 2 to 3 weeks after third cover spray.	Scab, powdery mildew----- Pecan weevil----- Aphids and mites-----	6-2-100 Bordeaux mixture or 65-percent dodine, 1 pound or 65-percent zineb, 2 pounds plus 1 quart summer-oil emulsion. 50-percent DDT, 6 pounds or 40-percent toxaphene, 6 pounds or 25-percent EPN, 2 pounds.	For best control of weevils, apply combination spray material when as many as six can be jarred from a tree; apply it again in 10 days to 2 weeks. Toxaphene may be mixed with zineb, but not with Bordeaux mixture. If sufficient aphids and mites are present to require control, use insecticides recommended on pp. 9, 10, and 20.
Fifth cover spray, about August 10 to 15.	Scab----- Hickory shuckworm-----	65-percent dodine, 1 pound--- or 65-percent zineb, 2 pounds plus 1 quart summer-oil emulsion. 25-percent EPN or Guthion, 2 pounds.	These applications will also control the leaf casebearer. In dry seasons, the fungicide for the sixth and seventh cover sprays for scab can be omitted.
Sixth cover spray, 2 weeks after fifth.	Scab----- Hickory shuckworm-----	Same as for fifth cover spray.	
Seventh cover spray, 2 weeks after sixth.	Scab----- Hickory shuckworm-----	Same as for fifth cover spray.	

The mention of commercial products in this publication does not constitute an endorsement by the U.S. Department of Agriculture over other products not mentioned.

NAMES OF PECAN INSECTS, DISEASES, AND CAUSAL ORGANISMS

Listed below are the common and scientific names of insects, diseases, and causal organisms discussed in this publication.

INSECTS

Common name	Scientific name
Hickory shuckworm	<i>Laspyresia caryana</i>
Pecan nut casebearer.....	<i>Acrobasis caryae</i>
Pecan weevil	<i>Curculio caryae</i>
Black pecan aphid.....	<i>Melanocallis caryaefoliae</i>
Black-margined aphid	<i>Monclia costalis</i>
Southern green stink bug.....	<i>Nezara viridula</i>
Leaf-footed bug	<i>Leptoglossus phyllopus</i>
Pecan leaf casebearer.....	<i>Acrobasis juglandis</i>
A spittlebug	<i>Clastoptera achatina</i>
Fall webworm	<i>Hyphantria cunea</i>
Walnut caterpillar	<i>Datana integerrima</i>
Twig girdler	<i>Oncideres cingulata</i>
Pecan phylloxera	<i>Phylloxera devastatrix</i>
Obscure scale	<i>Chrysomphalus obscurus</i>
A mite	<i>Eotetranychus hicoriae</i>
Pecan bud moth.....	<i>Gretchena bolliana</i>
Flatheaded apple tree borer.....	<i>Chrysobothris femorata</i>
May beetles or June bugs.....	<i>Phyllophaga</i> spp.
Red-shouldered shot-hole borer.....	<i>Xylobiops basilaris</i>
Hickory shoot curculio.....	<i>Conotrachelus aratus</i>
Other curculios.....	<i>Conotrachelus pecanae</i> and <i>hicoriae</i>

PECAN DISEASES AND CAUSAL ORGANISMS

Name of disease	Causal organism
Scab	<i>Fusicladium effusum</i>
Downy spot	<i>Mycosphaerella caryigena</i>
Vein spot	<i>Gnomonia nerviseda</i>
Leaf blotch	<i>Mycosphaerella dendroides</i>
Brown leaf spot.....	<i>Cercospora fusca</i>
Liver spot	<i>Gnomonia caryae</i> var. <i>pecanae</i>
Crown gall	<i>Agrobacterium tumefaciens</i>
Cotton root rot.....	<i>Phymatotrichum omnivorum</i>
Powdery mildew	<i>Microsphaera alni</i>
Nursery blight	<i>Elsinoe randii</i>
Pink mold	<i>Cephalothecium roseum</i>